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System for Faulty Battery Identification and Control

Abstract:

This publication describes systems and techniques to identify a faulty battery pack in a portable electronic device. Portable electronic devices, such as video game controllers and smartphones, are often powered by rechargeable lithium-ion or lithium-ion polymer battery packs. These battery packs must comply with various safety standards and regulations. As one example, one industry standard requires identification of a faulty battery pack and termination or non-initiation of battery charging. In some portable electronic devices, compliance with this standard (and other standards and regulations) requires additional or specialized hardware components that increase the cost of the electronic device and take up extra internal space. Disclosed in this publication is a portable electronic device that, during charging or initiation of charging, utilizes software logic to identify a faulty battery pack and take appropriate actions without additional or specialized hardware.

Keywords:

Battery pack, lithium-ion battery, Li-ion battery, li-ion polymer battery, rechargeable cell, fault, faulted mode, shut down, terminate, block, notification, alert, charger, fuel gauge, temperature, negative temperature coefficient thermistor, NTC thermistor.

Background:

Portable electronic devices, such as video game controllers, smartphones, tablets, laptops, handheld video game consoles, and electronic readers, generally operate with a rechargeable

lithium-ion or lithium-ion polymer battery pack. These battery packs must comply with various safety standards and regulations. For example, the Institute of Electrical and Electronics Engineers (IEEE) has established criteria for the qualification, quality, and reliability of rechargeable lithium-ion or lithium-ion polymer battery packs for cellular telephone applications in IEEE 1725-2011. The requirements in IEEE 1725-2011 include standards for the electrical and mechanical construction, packaging technologies, charge and discharge controls, and overall system considerations for battery packs. Section 7.3.2 of IEEE 1725-2011 requires identification of a faulted mode for the battery pack and, if the electronic device identifies a faulted mode, termination or non-initiation of battery charging. Hardware associated with the battery pack must interact with other components and the electronic device to assess and identify a faulted mode of the battery pack to satisfy Section 7.3.2. If the system detects a fault, the electronic device must cease or prevent initiation of charging, safely shut down, and notify the user.

In some portable electronic devices, the hardware components associated with the battery pack have limited inter-communications. As a result, these components do not comply with Section 7.3.2 of IEEE 1725-2011 (or other industry standards and regulations) without additional or specialized hardware. It is desirable to provide a technological solution that complies with the faulty-battery-pack criteria of Section 7.3.2 without incurring increased hardware costs.

Description:

This publication describes systems and techniques for identifying a faulty rechargeable lithium-ion or lithium-ion polymer battery pack to comply with Section 7.3.2 of IEEE 1725-2011 using a software solution without additional or specialized hardware. Portable electronic devices with a rechargeable battery pack generally include, among other components, a negative

temperature coefficient (NTC) thermistor, a charger integrated circuit (IC), and a battery fuel gauge associated with the battery system.

An NTC thermistor is often connected to a rechargeable lithium-ion or lithium-ion polymer battery pack in portable electronic devices. Electronic devices use NTC thermistors to monitor and control the temperature of battery packs while charging and prevent charging at temperatures that are too high or too low. Because the resistance of NTC thermistors decreases as the temperature of the battery pack increases, an electronic device can identify the battery-pack temperature by measuring the resistance of the NTC thermistor. For example, if the NTC thermistor malfunctions or the connection is cut, the NTC thermistor has an infinitely large resistance that the electronic device determines is caused by a low battery-pack temperature or a faulty NTC thermistor.

A charger IC is used to monitor and provide the correct charging current to the battery pack as a function of battery-pack temperature. The charger IC often utilizes the measured resistance of the NTC thermistor to determine the battery-pack temperature. By identifying the voltage drop across the NTC thermistor for a known charging current, the charger IC determines the resistance of the NTC thermistor and correlates the resistance to a battery-pack temperature. For example, a charger IC for a lithium-ion battery pack may decrease the charge current if the detected temperature is below 10°C or may prevent charging below 0°C.

A battery fuel gauge determines the state-of-charge of a battery pack by monitoring voltage, current, and temperature. A portable electronic device generally uses a fuel gauge to predict how much longer, under specific operating conditions, the battery pack will provide power. The fuel gauge can be a discrete component that is positioned some distance away from the battery pack. As a result, the detected temperature of the fuel gauge may be different than the detected

temperature of the IC charger, which utilizes the resistance of the NTC thermistor to determine the battery-pack temperature.

Charger ICs and fuel gauges often output the battery-pack temperature as a detected temperature level (*e.g.*, cold, cool, normal, warm, hot) as opposed to a specific numerical value (*e.g.*, 15.3°C). Table 1 (below) illustrates example temperature ranges associated with the detected temperature levels of a charger IC and fuel gauge.

Table 1: Temperature correlations for a charger IC and fuel gauge.

| Temperature output (Charger IC) | Temperature range | Temperature output (Fuel Gauge) |
|------------------------------------|-------------------|------------------------------------|
| T _{cold} | < 0°C | T _{cold} |
| T _{cool} | 0°C – 10°C | T _{cool} |
| T _{norm} | 10°C – 45°C | T _{norm} |
| T _{warm} | 45°C – 60°C | T _{warm} |
| T _{hot} | > 60°C | T _{hot} |

As discussed above, rechargeable lithium-ion and lithium-ion polymer battery packs must comply with numerous safety standards and regulations. Section 7.3.2 of IEEE 1725-2011, for example, requires identification, during charging, of a faulty battery pack and shutdown of the portable electronic device upon detecting a fault, along with user notification. Engineers may use additional or specialized hardware components to comply with the faulty-pack identification criteria of Section 7.3.2. The described systems and techniques, however, provide software means to satisfy the requirements of Section 7.3.2 without additional hardware by utilizing the NTC thermistor, charger IC, and fuel gauge already incorporated in the portable electronic device.

The described pack-identification systems and techniques may identify several potential cases of the battery pack, as illustrated in Figure 1. In Cases 1 and 2, the measured temperature of the charger IC is T_{cold} . This detected temperature may indicate that the NTC thermistor has been disconnected or has otherwise malfunctioned. In these cases, the charging of the battery pack is terminated or is not allowed to initiate.

In Case 1, the fuel gauge temperature output is T_{norm} . The difference between the measured temperature of the charger IC and the fuel gauge is two levels. The user interface of the electronic device notifies the user that the battery pack is faulty, and the electronic device shuts down. In Case 2, the gauge temperature output is T_{cool} , and the temperature-output difference is one level. The electronic device may remain active until the battery pack no longer has a charge or the electronic device is no longer connected to an external power source (*e.g.*, connected by a Universal Serial Bus (USB) cable to an electrical wall outlet).

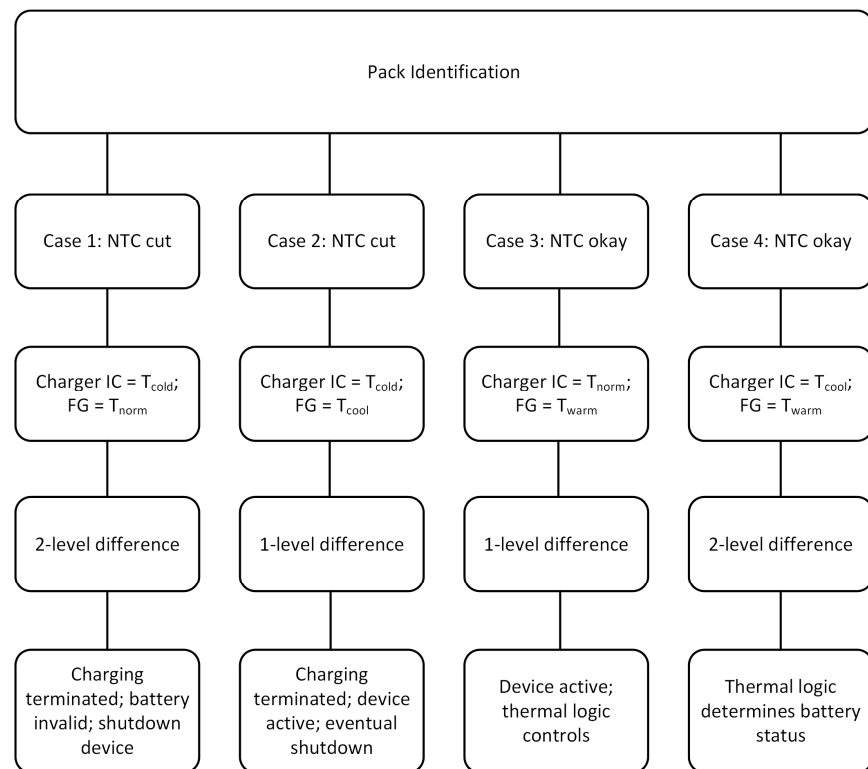


Figure 1

In Cases 3 and 4, the NTC thermistor has not malfunctioned, but the measured fuel gauge temperature is T_{warm} . The described pack-identification systems and techniques do not terminate charging in Cases 3 and 4. In Case 3, the measured charger IC temperature is T_{norm} , resulting in a one-level temperature difference. The electronic device remains active, and another battery-pack logic system (*e.g.*, thermal logic) assumes control. For example, a thermal logic may monitor the temperature of the battery pack during charging and limit the charging current based on the detected temperature. In Case 4, the measured charger IC temperature is T_{cool} , resulting in a two-level temperature difference. The two-level detected temperature difference may occur if the ambient temperature of the user environment is higher than the battery-pack temperature. In this situation, a different logic system monitors the detected temperatures and determines whether there is an error in the battery system.

An example flowchart of the described pack-identification logic is illustrated in Figure 2. The pack-identification logic begins by reading the detected temperature of the charger IC. If the temperature output by the charger IC is T_{cold} , the logic determines that the NTC thermistor may have faulted, resulting in a very large resistance value. The pack-identification logic then compares the detected temperature of the charger IC to the detected temperature of the fuel gauge. If the detected temperatures converge, then the pack-identification logic determines that the NTC has not faulted. If the detected temperatures do not converge, then the logic identifies that the battery pack is operating in Case 1 or Case 2 described with respect to Figure 1. If the fuel gauge temperature output is T_{norm} (Case 1), there are two levels of difference between the detected temperatures of the charger IC and fuel gauge, and the portable electronic device powers off. Before powering off, the user interface of the electronic device notifies the user that the battery is

faulty. If the fuel gauge temperature output is T_{cool} (Case 2), there is only one level of difference between the detected temperatures, and the electronic device remains active.

If the temperature output by the charger IC is T_{norm} , the pack-identification logic determines that the NTC thermistor is active and has not malfunctioned and the batter pack is operating in Case 3. The electronic device remains active and charging of the battery pack may continue or begin. In this scenario, the electronic device then compares the detected temperatures of the charger IC and the fuel gauge. If the fuel gauge temperature output is T_{warm} (Case 3), there is one level of difference between the detected temperatures, and the thermal logic assumes control.

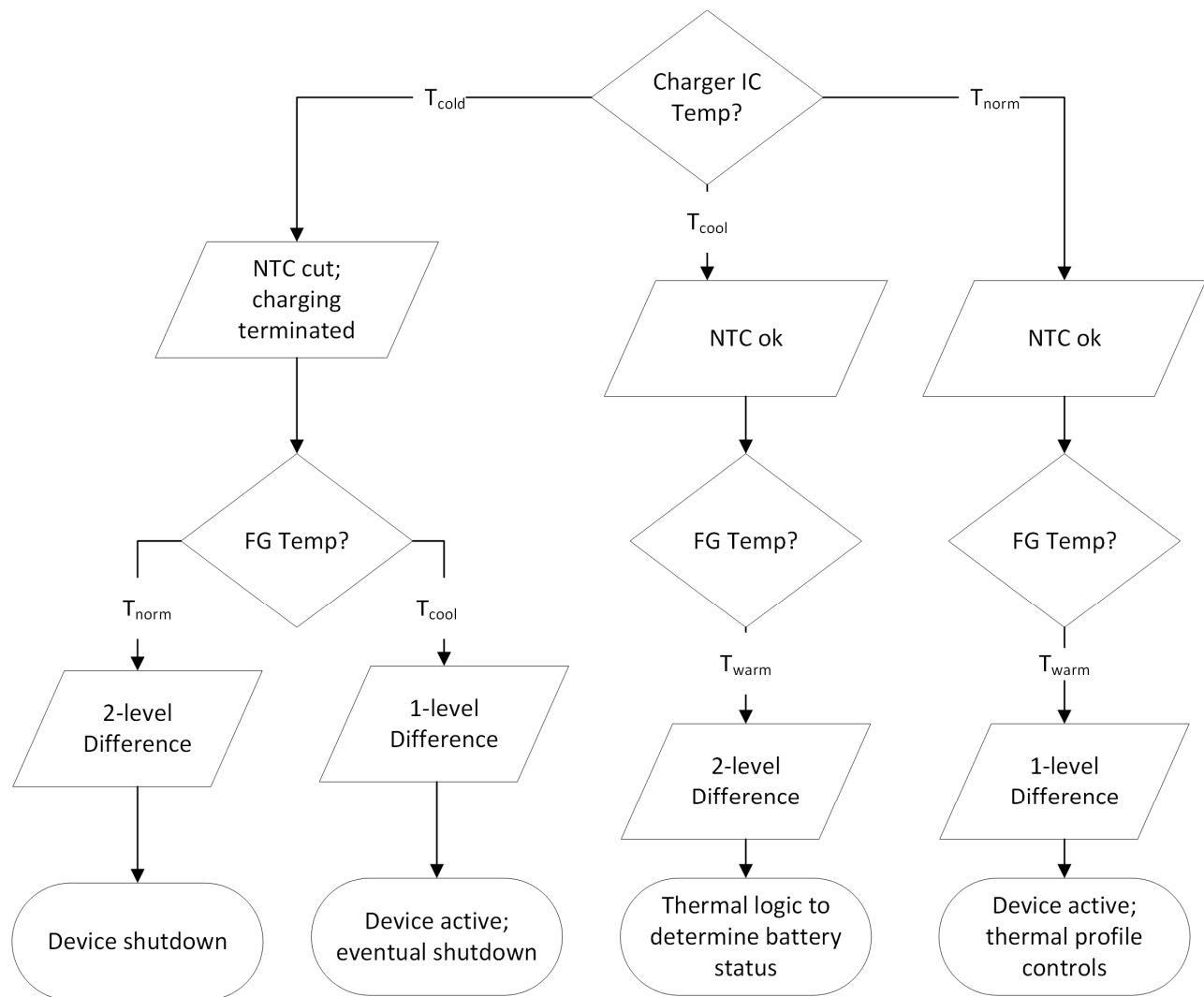


Figure 2

If the temperature output by the charger IC is T_{cool} (Case 4), the pack-identification logic similarly determines that the NTC thermistor is active and has not malfunctioned. In this scenario, the electronic device remains active. The fuel gauge temperature output is T_{warm} and there is a two-level temperature difference. Another battery logic system monitors the detected temperatures to determine whether there is a battery error.

In conclusion, the pack-identification logic identifies a faulty rechargeable lithium-ion or lithium-ion polymer battery pack of a portable electronic device and appropriately controls charging without additional or specialized hardware.

References:

- [1] Patent Publication: US20100121511A1. Li-ion battery array for vehicle and other large capacity applications. Priority Date: October 7, 2008.
- [2] “bq27532-G1 Technical Reference Manual: User’s Guide.” Texas Instruments Inc. October 2014. <http://www.ti.com/lit/ug/sluub04/sluub04.pdf>.